DRAFT ABI IRD

July 18, 2000

ADVANCED BASELINE IMAGER (ABI)

INTERFACE REQUIREMENTS DOCUMENT (IRD)

Prepared by

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ABI Interface Requirements Document

1.0 SCOPE

1.1 Introduction

The purpose of this Interface Requirements Document (IRD) is twofold. The first is to establish a baseline for interface requirements between GOES spacecraft and the ABI. Second, it serves as a core building block on which the sensor-to-spacecraft interface can be designed. The spacecraft integrating contractor and the sensor contractors **shall** each meet their respective interface requirements as defined in this document.

This IRD does not include much of the detailed information that will eventually be in an Interface Control Document (ICD). It only includes information that may be important in conducting a formulation study and will be significantly upgraded for and during the implementation phase work. The details of power, telemetry and command interfaces will generally not drive the design of the ABI but some information is included for the trade study. The thermal interfaces and mechanical disturbances may significantly affect the ABI design and are described in more detail.

The spacecraft-to-sensor interface requirements are broken down into four primary groups: mechanical, power, data, and thermal. In addition environmental, testing, contamination, launch and environment requirements are discussed.

This document after updating during the formulation study is to provide the basic interface requirements between the ABI, which will be developed first and a spacecraft that may be developed later. The Government will be the system integrator until a System Performance Responsibility contractor or Spacecraft contractor given that responsibility is selected. Until that time the government will be responsible for accommodation trades, resource allocation (weight, power, space, bandwidth, etc.), and resolving interface issues.

The ABI Performance and Operations Document (PORD) establishes the allocation of the system requirements to the ABI and defines the sensors' requirements
After award of the spacecraft integration contract, the sensor developer and the integrating contractor **shall** jointly write an Interface Control Document (ICD) which defines the details of the sensor-to-spacecraft interface and sensor accommodation information.

1.2 GOES System Overview

NOAA currently operates and maintains a Geosynchronous Earth Observing system, which nominally has two operational spacecraft in orbit, GOES-East and GOES-West. A good overview of the existing (GOES 8, 9 and 10) systems can be found in the Proceedings of SPIE - The International Society for Optical Engineering Volume 2812, 7-9 August l996, "GOES-8 and Beyond" and in Section 4 - GOES in SPIE Volume 3439, 19-21 July 1998. It should be noted the new series of GOES spacecraft N & Q are being developed by Hughes Spacecraft Corp. and have some significant differences in the details of the design and implementation from that described in some of the references.

The spacecraft to carry the ABI is not yet defined.

NOAA will provide and operate the Command and Data Acquisition (CDA) facility which receives the data from the GOES and a Satellite Operations and Control Center (SOCC) which operates the spacecraft and process the data for distribution to the users. The Government will provide the ABI Ground System (ABI-GS) that will calibrate, navigate and process the ABI data for distribution to the users.
The GOES spacecraft have extensive RF communication requirements but two that may have a significant impact on the design of the ABI are: (1) a Data Collection System that receives signals from small environmental platforms on the Earth's surface at rates up to few thousand bits/second in the frequency range of 401.9 to 402.2 megahertz and (2) a Search and Rescue transponder that receives even weaker signals at 400 bits/second in the frequency range of 406.05 to 406.025 megahertz. This IRD describes the emission limits that must be met by the ABI.

1.3 Requirement

The requirements stated in this document are not of equal importance or weight. The following three paragraphs define the weighting factors incorporated in this specification.

a. ***Shall*** designates the most important weighting level; that is, mandatory. Any deviations from these contractually imposed mandatory requirements require the approval of the contracting officer.
b. **Should** designates intermediate weighting for requirements requested by the government and are not mandatory. Unless required by other contract provisions, noncompliance with the *should* requirements does not require approval of the contracting officer but **shall** require documented technical substantiation.
c. ***Will*** designates the lowest weighting level. These *will* requirements designate the intent of the government and are often stated as examples of acceptable designs, items and practices. Unless required by other contract provisions, noncompliance with the *will* requirements does not require approval of the contracting officer and does not require documented technical substantiation.

The values specified in the IRD are one sigma unless specified otherwise.

This document contains firm interface requirements for the sensor except those labeled "(**TBD**)", "(**TBS**)", and "(**TBR**)". The term "(**TBD**)" applied to a missing requirement means that the contractor <u>should</u> determine the missing requirement in coordination with the government. The term "(**TBS**)" means that the government will supply the missing information in the course of the contract. The term "(**TBR**)" means that the requirement is subject to review for appropriateness by the contractor or the government. The government may change "(**TBR**)" requirements in the course of the contract.

2.0 APPLICABLE DOCUMENTS

The following documents of the exact issue shown form a part of this IRD to the extent specified herein. In the event of conflict between the documents referenced and the contents of this IRD, the latter **shall** be the superseding requirement.

2.1 Applicable Documents

CCSDS 203.0-B-1 January 87	CCSDS Recommendations for Space Data System Standards. Telecommand, Part 3: Data Management Service, Architectural Definition, Issue 1
CCSDS 701.0-B-2 October 1989	Consultative Committee for Space Data Systems (CCSDS) Recommendations for Advanced Orbiting Systems (AOS), Networks and Data Links: Architectural Specification
MIL-STD 1553B	????? (see 3.5.1.1.7.1)
MIL-STD-1541A	Electromagnetic Compatibility Requirements for Space Systems
I^2C	?????? (see 3.5.1.1.7.1)
S-415-201	GOES Advanced Baseline Imager- Performance and Operation Requirements Document
MIL-STD-461 Notice 1	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462 Notice 1	Measurements of Electromagnetic Interference Characteristics
MIL-STD-882c January 93	System Safety Program Requirements
CCSDS/SOIF	Draft US position paper for CCSDS
X2000 Interface Req.	X2000 Interface Req.
NPOESS SRD	NPOESS Common Section of the Sensor Requirements Document
MIL-STD-463A	Definitions and System of Units, Electromagnetic Interface and Electromagnetic Compatibility Technology (Ref) Contamination Control
MIL-STD-1547A December 92	Electronic Parts, Materials, and Processes for Spacecraft and Launch Vehicles
IEEE-1394-1995	
GSFC X-900-97-004	Charged Particle Radiation Exposure of Geostationary Orbits (Stassinipoulos, Barth, and Nakamura 1997)
MIL-B-5087	Bonding, Electrical, and Lighting Protection for Aerospace Systems
FED-STD-209E	Airborne Particulate Cleanliness in Clean rooms and Clean Zones

3.0 ABI Interface Requirements

3.1 General

3.1.1 Configuration

The ABI is an eight (to 12) spectral channel, two axis scanning (or stepping) radiometer designed to provide variable area imagery and radiometric information of the Earth's surface, atmosphere and cloud cover. The ABI collects data on a three-axis body stabilized satellite in geosynchronous orbit. Capability for star sensing by the ABI is required. The ABI is designed to measure emitted and solar reflected radiance simultaneously in all spectral channels. Data availability, radiometric quality, simultaneous data collection, coverage rates, scan flexibility, and minimizing data loss due to the sun, are prime requirements of the system. The ABI requires primary power and decoded command input data from the spacecraft. ABI output data are a continuous (?) data stream containing sensor information and other telemetry data.

The ABI may consist of multiple modules. The present GOES Imager consists of three separate modules. The sensor module contains the optical system, scanner, detectors and their cooling systems, and directly related electronics. The electronics module and power supply module contain power, command, control, and data processing circuitry. The ABI sensor module **shall** be mounted external to the spacecraft body; an electronics module and/or a power supply module if required by the ABI may be mounted either external or internal to the spacecraft body.

3.1.2 Mass, Power, Volume

The following information on Mass, Power and Volume represent the characteristics of the Imager for the GOES-Q mission and are presented for information and should be considered "goals" until further refined early in the formulation study.

The total ABI mass should be no more than 125 Kilograms (TBR) including all associated electronics, cabling and power supplies.

The ABI should consume no more than 256 (TBR) watts under all operating conditions. Specifically, no power (TBR) in Launch Mode, minimal power (TBR) in Sensor Off mode, Moderate power (TBR) in Sensor Safe Hold mode and full power in sensor Diagnostic and Operational modes.

The ABI components' dimensions in the stowed and operational configurations (not including any required kinematic mounts), mass and power should be no more than listed in the following table. Paragraph 3.2.3.4 has more information on deployable covers.

Table 3.1.2-1 ABI components Size, Mass and Power

Component	Width	Height	Depth	Mass	Power
ABI Sensor	**115 cm**	69 cm	69 cm	90 kg	**TBD** W
ABI Electronics	43 cm	20 cm	67 cm	30 kg	90 W
ABI power supply	24 cm	17 cm	28 cm	5 kg	30 W
Sensor Parallel to	X-Axis	Y-axis	Z-axis		

3.1.3 Instrument Reference Coordinate Frame

A right-hand, orthogonal, body-fixed XYZ coordinate system **shall** be used. The +Z-axis is downward towards nadir, the Y-axis is approximately along the orbit normal (+Y is opposite the orbital angular momentum) and the X-axis is along the spacecraft velocity vector (+X toward the direction of spacecraft travel). The X-axis and Y-axis reverse directions relative to the orbit with the yaw flip. Roll, Pitch and Yaw are rotations around the X, Y and Z axes respectively.

3.1.4 Dimension Unit Standard

All documents **shall** provide units in metric as the minimum, with English units added for clarification, as an option. All interfaces **shall** be specified in the international system of units, Systém International (SI). Dimensioning **shall** be in the as-designed units. For angle measurements Degrees are acceptable but not arcseconds and arcminutes. Radians, microradians (μrad or urad) are acceptable.

3.1.5 Nominal Orbital parameters

The ABI will be in a geosynchronous orbit. The GOES spacecraft will have a maximum inclination of 1 degree, be no more than 0.5 degrees from the desired (fixed grid) longitude and have a maximum eccentricity of 0.0012. The nominal locations are 75° and 135° west

3.1.6 Launch Vehicle Compatibility

The ABI **shall** be compatible with an expendable launch vehicle. Orientation of the ABI modules at launch **shall** be such that the launch loads applied to each axis do not exceed the allowable levels.

3.2 Mechanical

3.2.1 Mass Properties

The mass of the instrument and modules **shall** be measured to +/-0.l kg.

3.2.1.1 Moment of Inertia

The moments of inertia **shall** be calculated for two mission configurations. These include the "stowed" configuration, in which the sensor module covers are closed, and the "deployed" configuration, in which the sensor module covers are open. Moments of inertia values **shall** be accurate to within ± 10% (**TBR**)

3.2.1.2 Center of Gravity

The nominal center of gravity locations for the modules **shall** be provided to spacecraft contractor. The launch and on-orbit center of mass of each instrument and module **shall** be measured and reported to ± 0.5 cm.

3.2.2 Mounting and Alignment

3.2.2.1 Sensor Module

Sensor module **shall** be mounted using kinematic mounts unless the instrument provider demonstrates that kinematic mounts are not required. Mounting requirements **shall** be documented in the ICD.

The ABI **shall** have an alignment cube visible from two orthogonal directions provided by the instrument contractor to enable the alignment of the sensor assembly to the satellite.

3.2.2.2 Electronics Module and Power Supply Module

The interfaces among the satellite and the electronics and power supply modules, if used, **shall** be described on their respective interface control drawings. The electronics and power supply modules do not have specific alignment requirements.

3.2.3 Fields of View

Unless otherwise noted, the following fields of view are defined with respect to normal geosynchronous orbit operations.

3.2.3.1 Optical Port Field of View

The spacecraft design **shall** provide the ABI an unobstructed optical port FOV within a conical 65° half angle of optical nadir (with respect to the edges of the optical port sunshield) to minimize collection of scattered energy.

3.2.3.2 Sunshields

The sensor module design may include sunshields which reduce the amount of solar energy that reaches the instrument during the hot portion of the geosynchronous orbit (spacecraft local night) during normal operations. These sunshields **shall** fit within the specified envelope. The optical port sunshield is attached to the instrument's earth-viewing face, shading the optical port, to reduce the amount of direct solar radiation entering the scan cavity. The ABI sunshield **shall** not enter the field of view of the Sounder Instrument which may be mounted near (head to head for GOES-N) to the ABI.

3.2.3.3 Radiant Cooler Field of View (if Required)

The spacecraft **shall** provide the ABI with a FOV approximately normal to the orbital plane suitable for mounting a radiant cooler to cool its IR detectors. This FOV **shall** be a minimally obstructed hemispherical FOV, pointing to the north in the winter and to the south in the summer. (The spacecraft **shall** implement two 180^{o} yaw flips per year to achieve this orientation.) The thermal input onto the radiant cooler surfaces from the spacecraft will be near zero and controlled.

3.2.3.4 Deployable Covers

The detector's radiant cooler and the ABI aperture may have a deployable cover if required to protect the system from contamination or excessive temperatures during launch and transfer into geosynchronous orbit. These covers must be latched when deployed and **shall** not extend beyond the ABI's allowable envelope unless approval is given by the government to do so.

3.2.3.5 Prelaunch Cleaning Access

Several areas of the ABI sensor module may require special access for cleaning. Although the sensor module is manufactured in a manner to minimize the accumulation of contamination, cleaning of the sensitive surfaces may still be required to maximize performance. The spacecraft and ground handling equipment **shall** be designed to allow access to the following areas until the final preparation-for-launch closeout:

1) Optical port cavity for cleaning of the accessible telescope mirrors, scan mirror, and the optical cavity surface
2) The optical solar reflector (OSR) surfaces, if used.

3.2.3.6 Potentially Hazardous Solar Intrusions into Fields of View

The following is a list of potentially hazardous solar intrusions into the ABI instrument FOVs.

1) See the GOES ABI Performance and Operations Requirements Document, sections 3.1.4.4 (Zones of Reduced Data Quality) and 3.1.4.5 (Scanning Through the Sun) for solar input into the optics.

2) With cooler door (if used) deployed (open), the sun at angles above the radiant cooler plane during any single exposure as follows (radiant cooler heating concern):

a. <2°: no restrictions on exposure; Instrument must meet all of it's performance specifications
b. >25° (**TBR**): no exposure permitted
c. >2° and <25° (**TBR**): exposure < 16 minutes for any one incident.

3.2.4 Mechanical Disturbances and Handling

3.2.4.1 Spacecraft-to-Instrument Disturbances

Because the ABI sensor module contains sensitive and precisely aligned optical components, its performance can be greatly affected by mechanical disturbances (both linear and angular) imparted by the spacecraft to the instrument feet. Low frequency angular disturbances below **TBD** Hz rates translate directly into pointing errors if uncompensated via Image Motion Compensation (IMC) in the sensor or in the ground processing. High frequency angular disturbances above **TBD** Hz and linear disturbances at all frequencies can modulate instrument optical alignment causing artifacts in the image. The total angular disturbances from all sources **shall** be limited to the values in Figure 3.2.4-1 (**TBR)** for the given frequencies. These disturbances include (but are not limited to) effects from solar array drives, momentum and reaction wheels, gyros, other payload mechanisms, and spacecraft thermal "snapping". The curve defines the maximum spacecraft inputs into the ABI mounting surface. In the current spacecraft the largest amplitude angular disturbance occurs when the current Sounder performs a Black Body Calibration. This starts as a linear ramp around the spacecraft Roll axis of about 10 microradians per second lasting for about 18 seconds. Real time measurements of this and other motions are included in the Spacecraft Motion Compensation (SMC) signal that estimates the motion of the spacecraft navigation base and is sent to the ABI.

The maximum allowable linear disturbances from the spacecraft to the sensor module mounting panel during orbital operations **shall** be as specified in Table 3.2.4-1 (**TBR)**.

Table 3.2.4-1 Maximum Allowable Sinusoidal Disturbance

Accelerations from Spacecraft to Instrument (RMS), mG

Axis	Below 45 Hz	45 Hz–120 Hz	Above 120 Hz
X	5.0	0.35	1.2
Y	6.4	1.0	1.0
Z	2.3	0.64	1.0

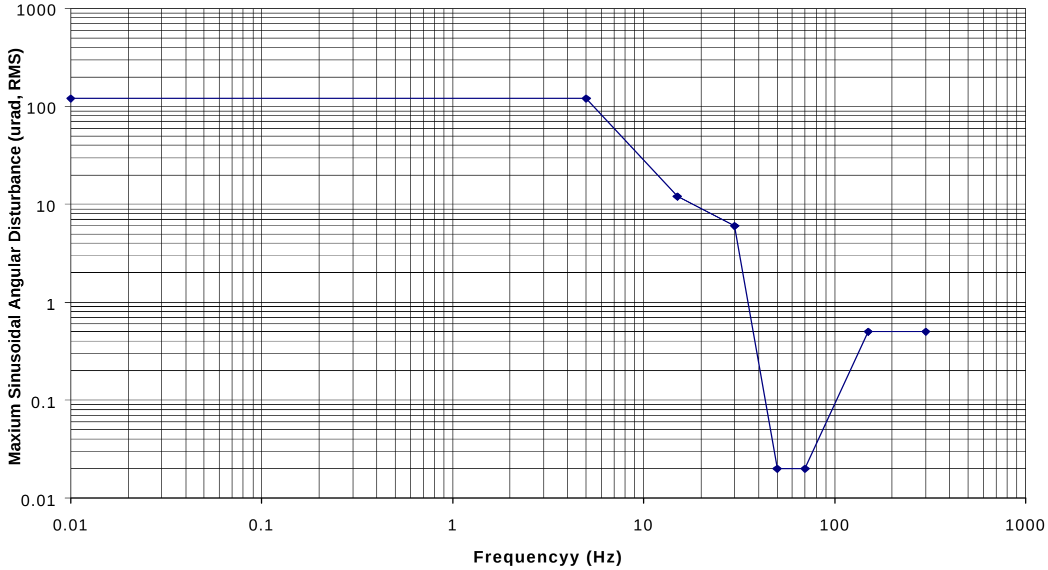


Figure 3.2.4-1 ABI Imager: Envelope of Maximum Sinusoidal Disturbances (TBR).

3.2.4.2 Instrument to Spacecraft Disturbances

Due to the dynamic nature of the ABI sensor module during on-orbit operations, the ABI may impart disturbances to the spacecraft. The instrument may contain a moving mass with **TBD** mass, inertia and torque.

Torque disturbances imparted to the spacecraft originating from the ABI instrument scanner **shall** be less than +/-0.8 Newton meters (+/- 7 in-lb.). The duration of the disturbances **shall** not exceed 0.1 seconds. Smaller torques may be applied for proportionally longer periods of time. The torques represent net torque transmitted to the spacecraft by motors less any bearing and flexible wire assembly drags or torsions internal to the instrument that the motors work against.

3.2.4.3 Uncompensated Momentum

The Instrument(s) **shall** have a maximum continuous uncompensated momentum of 0.81 Newton-meters-seconds (0.6 ft-lb-sec) allowed in the S/C pitch axis (Y-axis) and 0.081 Newton-meter-seconds (0.06 ft-lb-sec) in the S/C roll/yaw axis. The 0.081 Newton-meter-seconds (0.06 ft-lb-sec) allows for misalignment of the Instrument(s) momentum vector relative to the S/C for yaw and roll axes.

3.2.4.4 Mechanical Handling

The instrument contractor **shall** provide specific lifting points on the sensor and modules, which **shall** allow handling with an overhead crane. A minimum of three lifting points **shall** be provided that allows the mounting surface to be in a horizontal attitude during installation.

3.2.4.4.1 Handling Fixtures

The instrument contractor **shall** provide proof tested handling fixtures for each instrument and module weighing in excess of 16 kg (35 lbs).

Handling fixtures **shall** be designed to 5 times limit load for ultimate and 3 times limit load for yield. Handling fixtures **shall** be tested to 2 times working load.

3.2.5 Instrument and Module Structural Dynamics

3.2.5.1 Minimum Fixed-Base Frequency

Each separately mounted instrument and module, configured for launch, **shall** have a fixed base frequency of ≥ 50 Hz. Fixed base is defined as follows: Each mounting point **shall** be constrained in those degrees of freedom which are rigidly attached to the spacecraft, and **shall** be free in those degrees-of-freedom for which kinematic mounts or flexures provide flexibility.

3.2.5.2 Low Mass Component Fixed-Base Minimum Frequency

Each separately mounted instrument and module with a mass of less than 22.7 kg (50 lbs) **shall** have a fixed-base frequency of ≥ 100 Hz.

3.2.6 Interface Design Limit Loads Requirements

3.2.6.1 Limit Loads Application

Limit loads **shall** be applied at the center of mass (CM) of the instrument or module, configured for launch, to design the mounting interface.

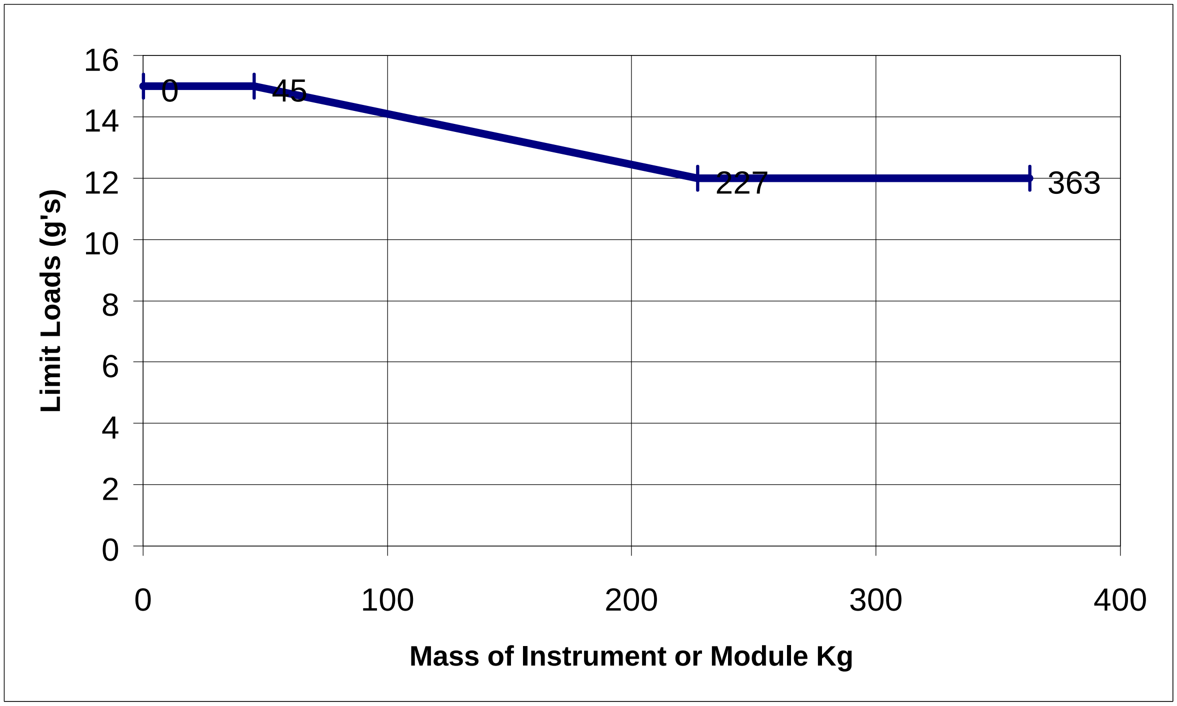
3.2.6.2 Limit Loads Application Axis

The loads **shall** be applied in one direction in such a way as to produce the maximum stresses at the interfaces.

3.2.6.3. Interface Limit Loads

The limit loads **shall** be based on the mass of the instrument or module as defined in Figure 3.2.6.3-1

Figure 3.2.6.3-1 - Design Limit Load vs. Instrument and Module Mass



3.2.6.3.1 Design Limit Loads

The design limit loads **shall** be multiplied be a factor of 1.4 to obtain the ultimate design loads, and by 1.25 to obtain the yield design loads.

3.2.6.3.2 Qualification Loads

The verification limit loads derived from the final coupled loads analysis **shall** be multiplied by a factor of 1.25 to obtain qualification test loads.

3.2.7 Instrument Mechanisms

All instrument mechanisms, which require restraint during launch, **shall** be caged during launch without requiring power to maintain the caged condition.

3.2.7.1 Caging During Test and Launch

Instrument mechanisms, which require caging and/or uncaging during test and launch site operations **shall** be capable of being uncaged by command and recaged by command or by manual actuation of accessible locking/unlocking devices.

3.3 Thermal

3.3.1 Allowable Temperatures

The ABI qualification, cold start, orbit raising and mission allowable temperatures are **TBD**. The spacecraft and ABI instrument design **shall** provide a thermal interface and mission design that maintains the ABI temperature as defined in the following cases:

- <u>Under all Geosynchronous orbit conditions, including on-orbit storage and safe hold mode</u> - within the mission allowable temperature range
- <u>During launch and orbit raising activities</u> - above the orbit raising temperatures and below the acceptance high temperatures
- <u>For any ABI turn-on</u> - above the cold start temperature limits
- <u>During spacecraft-level environmental testing</u> - within the acceptance high/low acceptance temperature range.

3.3.2 Instrument Thermal control Design

The ABI sensor module **shall** be thermally isolated from the sensor module's mounting surface and from other objects on the spacecraft (TBR). The spacecraft **shall** be capable of accepting the heat from the electronics or power supply module (if used) and controlling the temperature of the mounting surface of the modules to qualification level temperatures between -20 and +55 C for the electronics module and -20 to +60 C for the power supply. The nominal mission allowable mounting surface temperatures **shall** be -5 to +40 C for both modules. The sensor module thermal design features **shall** be considered in the design of the spacecraft interface.

The mission allowable temperature range is that predicted and/or measured for orbital operation, with uncertainties over the life of the mission. The acceptance test range is 5 degrees C more extreme than the mission allowable temperature range to allow for production variability. The qualification test range (for the protoflight or first instrument) is 10 degrees C more extreme than the mission allowable temperature range. The cold start and orbit raising test temperatures are 10 degrees more extreme than the low qualification temperature for electronics and power suupply modules and up to 7 degrees more extreme than the low qualification temperature of the sensor module.

3.4 Electrical

3.4.1. Grounding

Within the instrument, all electronic (power) returns consisting of pulse command returns, bilevel telemetry returns, instrument primary power return, and instrument secondary power returns **shall** be isolated from chassis (>100 kΩ) and from each other. Each of these returns may receive their reference to chassis on the spacecraft side of the interface.

3.4.2 Test Connectors

Test points **shall** be provided by the instrument to facilitate testing and ensure conformance with the system specification.

A separate test connector **shall** provide the means to verify the instrument power input fuse integrity. All test points **shall** be internally buffered so that the instrument performance is not affected when monitoring. Short circuit protection of all test points **shall** be provided. The instrument **shall** operate within specification while a test point is shorted to ground.

The spacecraft **shall** provide access to the electronics module (if used by the ABI) test connectors while the instrument is mounted on the spacecraft. The spacecraft contractor **shall** provide the test cables necessary to access the electronic module test connectors while the instrument is mounted on the spacecraft. The spacecraft **shall** provide access to the wires from instrument mounted accelerometers and thermocouples. The accelerometer and thermocouple wires **shall** be removed or terminated at the conclusion of spacecraft testing.

All digital test connectors for the "Standard Interface" **shall** be either Ethernet or UART (RS-422).

3.4.3 Power

The spacecraft **shall** provide +28VDC (**TBR**). power to the ABI through a single instrument power connector.

3.4.3.1 Instrument Power Consumption

The following sections specify the maximum power that the instrument **shall** draw from the spacecraft at BOL. The instrument's EOL power consumption **shall** not exceed the maximum BOL values by more than 5%.

3.4.3.2 Steady-State BOL Power

The maximum steady state BOL power (excluding scan transients) from the instrument **shall** not exceed **TBD** watts.

The instrument's cooler outgas and anticontamination heaters **shall** provide thermostatic and (ON-OFF) control and **shall** draw no more than the maximum power (Wmax= **TBD**)).

3.4.3.3 Transient Currents

The peak currents produced on the instrument power input by the instrument **shall** not exceed **TBD** amperes. The transient currents values represent absolute bus currents with steady state current subtracted out, the AC portion of any transient current **shall** be less than **TBD** amperes and **shall** have a rate of change of less than **TBD** amps per μsec.

3.4.3.4 Average Power Draw While Scanning

For the ABI, the average power draw while scanning a normal observation sequence of a two full disk and six CONUS frames plus any required overhead in 30 minutes **shall** be less than **TBD** Watts. When CONUS coverage is replaced by 1000x1000km frames the average power **shall** be **TBD** watts.

3.4.3.5 Power Dissipation of an electronics and power supply module (if used)

The maximum power dissipation for the electronics and power supply modules **shall** be **TBD** watts and **TBD** watts, respectively.

3.4.3.6 Fuses

Redundant, testable in place, easily replaceable, fuses **shall** be in the ABI.

3.4.4 Electromagnetic Compatibility

The spacecraft and instrument **shall** be designed for EMC using MIL-STD-1541 and MIL-STD-461 as design guides. Conformance to EMC requirements **shall** be verified on both electronics Side 1 and Side 2 of every flight unit, except when noted otherwise, using MIL-STD-462 as a guide.

3.4.4.1 Steady-State CE of Power Line

The spacecraft **shall** be able to tolerate the maximum steady-state narrow band conducted emissions (CE) generated by the instrument, while performing a normal frame scan, and fed back to the instrument's power input. The instrument's power line steady-state CE **shall** not exceed the values shown in Figure 3.4.4-1, which contain 12 dB margin over prior instrument test results above 300 Hz. This requirement applies from 30 Hz to 1 MHz at the measurement bandwidths shown in Figure 3.4.4-1.

3.4.4.2 Selected Signal Lines Conducted Emissions

The spacecraft **shall** be able to tolerate the maximum peak-to-peak Conducted Emissions (CE) generated by the instrument. The instrument's CE on Selected Signal Lines **shall** not exceed the values shown in Table 3.4.4-1. This requirement applies to the output signals, electronic sides, and the scan operating modes defined in the Table 3.4.4-1.

This requirement applies only to the limited number of selected spacecraft-to-instrument interface signals shown in the table.

Table 3.4.4-1 CE of Selected Signal Lines

Instrument Output Signal	Scan Operating Mode	Maximum CE (DC to 5 MHz Bandwidth)
Proportional Command Data Strobe	Servo Off	≤150 mVp-p
Scan Status E-W Scan Direction E-W Slew Status N-S Scan Direction N-S Slew Status	Normal Frame	≤250 mVp-p
Mirror Position Data	Idle	≤250 mVp-p
Wideband Data	Idle	≤150 mVp-p
Bilevel Telemetry Frame Status Space Look Status	Idle and Star Sequence	Logic "1" ≤100 mVp-p Logic "0" ≤50 mVp-p
Analog Telemetry Baseplate Temperature #1 +17V Electronics	Star Sequence	≤20 mVp-p

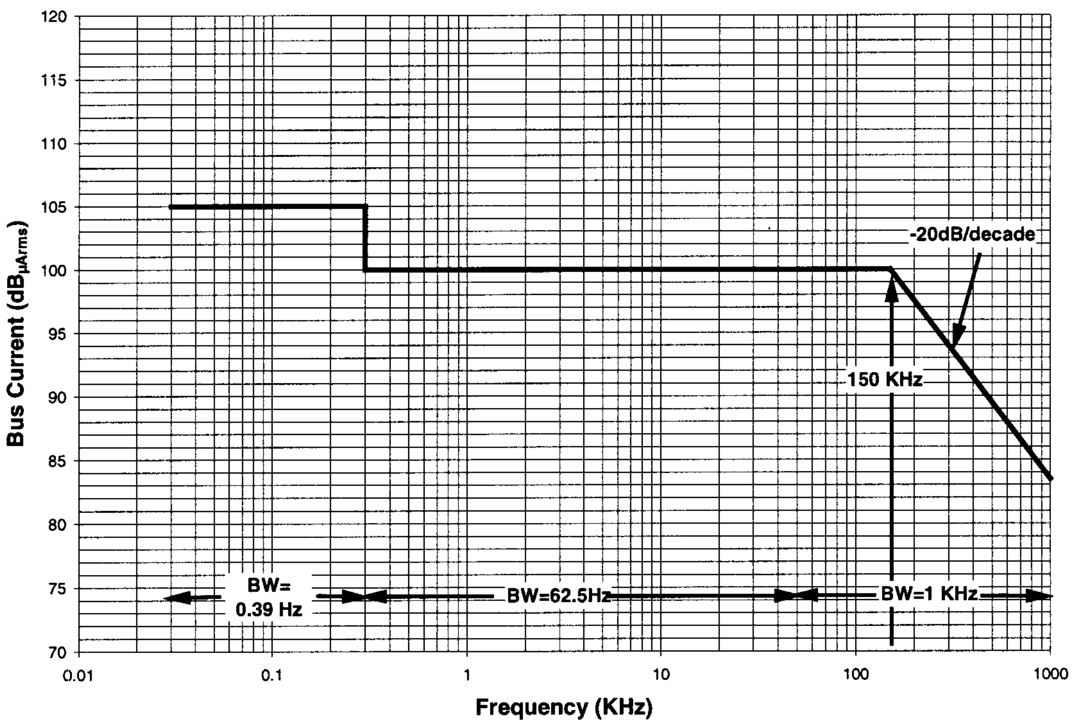


Figure 3.4.4-1 Steady-State CE of Power Line

3.4.4.3 Steady-State CS of Power Line

The spacecraft **shall** provide the instrument with a power input with interference levels below the instrument's specified power line steady-state conducted susceptibility (CS), which is shown in Figure 3.4.4-2. This requirement excludes noise voltages caused by conducted emissions from the instrument itself. Only additive noise generated by the spacecraft itself should be tested to this requirement. The instrument **shall** meet all performance requirements when subjected to the steady-state narrowband interference voltage superimposed upon the instrument's power input voltage as shown in Figure 3.4.3-2. This requirement applies from 1Hz to 5 MHz.

3.4.4.4 CS of Selected Signal Lines

The spacecraft **shall** provide the instrument with the specified signal inputs having interference levels below the instrument's conducted susceptibility (CS) as specified for selected signal lines as shown in Table 3.4.4-2. The instrument **shall** meet the performance requirements stated in this section when subjected to the steady-state narrowband interference voltages superimposed upon the instrument input signals as shown in Table 3.4.4-2. This requirement applies only to the signals specified in this section. The conducted susceptibility requirement is constant at 200 mV or 100 mV, whichever applies, from 1 Hz to 150 kHz, and rolls off at –20dB/decade from 150 kHz to 400 kHz. The conducted susceptibility requirement for these signals is satisfied if the echoed data in the instrument output data stream matches the original inputs.

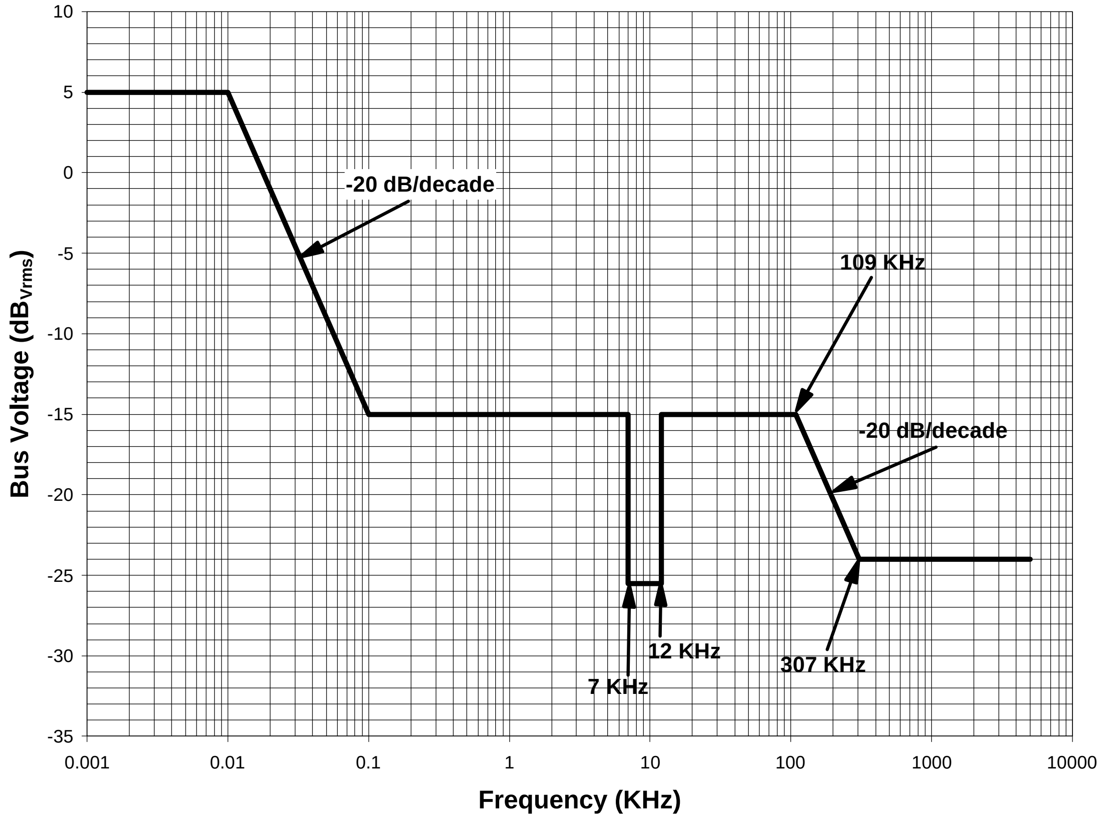


Figure 3.4.4-2 Steady-State CS of Power Line

Table 3.4.4-2 CS of Selected Signal Lines

Instrument Input Signal	Scan Operating Mode	Interference Amplitude
Proportional Command Data Ready Data	Scan OFF	Logic “1” = 200 mVp-p Logic “0” = 100 mVp-p
S/C Attitude Data (INR1) Timing Gate Clock Data	Star Sequence	Logic “1” = 200 mVp-p Logic “0” = 100 mVp-p

3.4.4.5 Common Mode Voltage Noise

The maximum spacecraft generated common mode noise between chassis and instrument secondary return as measured at the instrument interface **shall** not exceed the levels specified in Table 3.4.4-3 when measured with the instrument disconnected.

Table 3.4.4-3 Common Mode Voltage Noise

Band	Measurement Method	Frequency Range	Maximum Level
Broadband	Oscilloscope (Bandwidth = 400 MHz)	Up to 400 MHz	0.5V peak-to-peak
Narrowband	Spectrum Analyzer (Measurement BW = 1 kHz)	4 kHz to 1 MHz Above 1 MHz	±10mV peak ±100mV peak

3.4.4.6 Radiated Emissions of Instrument - Example from GOES-N Imager and Instrument of Opportunity ICD

The instrument's maximum Radiated Emissions, frequency ranges, and measurement bandwidth specifications **shall** be as shown in Table 3.4.4-4. The radiated emissions from the instrument are specified at a distance of 1 meter from the sensor module's optical port while the instrument is operating. The spacecraft carries two very sensitive receiving systems operating in the 400 MHz region, Search and Rescue and Data Collection System, which require the very low emissions in that region. Unintentional radiated narrowband electric field levels produced by Instrument **shall** have a level in a 100 Hz resolution bandwidth from 401.7 MHz to 402.4 MHz, and 406 MHz to 406.1 MHz, for a dipole antenna placed 1 meter from the Instrument under test, in accordance with test method RE02 of MIL-STD-462, that is no greater than -140 dBm. The specific frequencies and power levels in tables 3.4.4-4 and 3.4.4-5 are **TBR** and will not be refined until the higher power spacecraft communication systems are designed.

Table 3.4.4-4 Radiated Emissions of Instrument

Frequency Range		Measurement Bandwidth	Field Strength, dBμV/m
Lower Frequency	Upper Frequency		
14 kHz	2.4 MHz	1 kHz	54
2.4 MHz	30 MHz	10 kHz	60
30 MHz	200 MHz	100 kHz	76
200 MHz	1 GHz	100 kHz	62
1 GHz	10 GHz	1 MHz	72
401.700 MHz	402.400 MHz	100 Hz	–10
406.000 MHz	406.100 MHz	100 Hz	–13
2025.600 MHz	2029.800 MHz	100 Hz	0
2032.950 MHz	2033.050 MHz	100 Hz	0
2034.150 MHz	2034.250 MHz	100 Hz	0
2034.850 MHz	2034.950 MHz	100 Hz	0

3.4.4.7 Radiated Susceptibility of Instrument - Example from GOES-N Imager ICD

The spacecraft **shall** not produce radiated interference levels (**TBR)** in excess of the radiated susceptibility (RS) of the instrument as defined in Table 3.4.4-5. The requirement applies at the frequencies shown in Table 3.4.4-5 at two source positions, using a MIL-STD-462, RS03 test method setup:

1) The source positioned 1 meter from the sensor module's optical port.

2) The source positioned 1 meter from the sensor module's radiant cooler.

The RS requirement is satisfied if the noise increase is such that the NEΔT, SNR, and pointing accuracy requirements would still be met.

Table 3.4.4-5 RS Test Frequencies and Field Strengths

Function	Frequency, MHz	Field Strength (50% Modulated with 1khz signal), V/m
DCPI Repeater	468.800	0.6
SAR Repeater	1544.500	1.0
Sensor Data	1676.000	1.0
MDL Data	1681.480	1.0
PDR Repeater	1685.700	1.0
WEFAX Repeater	1691.000	1.0
CDA Telemetry	1694.000	1.0
DCS Pilot Report	1694.450	1.0
DCPR Repeater (Domestic)	1694.500	1.0
DCPR Repeater (International)	1694.800	1.0
Telemetry DSN	2208.586	1.0
Telemetry DSN	2209.086	1.0

3.4.4.8 Electrostatic Arc-Discharge Susceptibility

The spacecraft **shall** be designed to minimize the occurrence of ESD events on the instrument and **shall** not allow discharges greater than the maximum specified for the instrument.

The instrument **shall** be designed to withstand both a radiated and direct arc as shown in Table 3.4.4-8 without sustaining permanent damage. The direct arc-discharge can occur on any of the 5 exposed surfaces of the three instrument modules. Instrument operation **shall** not be impaired after the arc discharge

Table 3.4.4-8 ESDS Characteristics

Item	Description	Characteristics
1	Discharge Voltage	10 kV
2	Discharge Energy	3 millijoules maximum
3	Peak Current	1 Amp
4	Time Constant	600 nsec
5	Repetition Rate	1 sec
6	Quantity of Discharges per Surface	≥30

Item	Description	Characteristics
7	Distance of Radiated Discharge from Instrument Surface	30 cm

3.5 Standard Interfaces vs. Current "Conventional " GOES Interfaces

This section describes the proposed interface standard and the current "conventional" GOES interface and will be updated after the GOES Project reviews the ABI trade studies on implementing standard interfaces on the GOES ABI instrument. Section 3.5.1 refers to standard interfaces and Section 3.5.2 refers in the current GOES interfaces.

3.5.1 Standard Interface Requirements

The ABI **shall** provide a minimum of two (2) interfaces: One for the exchange of commands, engineering data, spacecraft measured instrument mounting surface angular motion and spacecraft attitude error data and a second for the downlink of ABI sensor data and ancillary data. In addition, conventional interfaces **shall** be provided for the monitoring of critical analog instrumentation such as thermistor data and initiating control of the instrument. Standard ground support interfaces principally used for the loading/dumping of any ABI processor memory are included. Figure 3.5-1 shows the proposed standard interfaces.

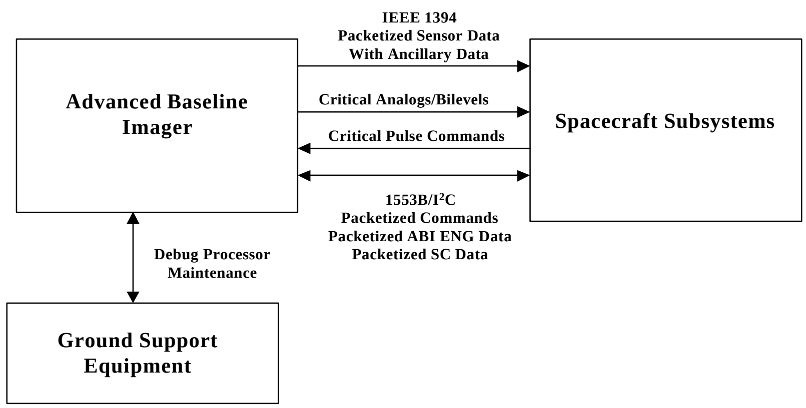


Figure 3.5-1 Proposed ABI Standard Interfaces

3.5 1.1 Standard High Speed Interface for Sensor Data

Redundant IEEE 1394 interfaces **shall** be used for the transmission of all formatted ABI imagery and ancillary data for downlink and/or recording by the spacecraft.

3.5.1.1.1 Maximum Aggregate Data Downlink Rate

The maximum aggregate data rate of all ABI formatted downlink data, including any spacecraft provided ancillary data **shall** be not exceed an average rate of 15 Mb/s (**TBR)** at a burst rate of 100 Mb/s (TBR) on the high speed buss.

3.5.1.1.2 High Speed Data Packetization and Data Content

The ABI **shall** format all sensor data into CCSDS source packets. The ABI instrument **shall** format any spacecraft provided housekeeping data, attitude data and instrument mounting surface angular motion data into CCSDS packets. The data stream **shall** contain sufficient ABI information to fully process the ABI image.

3.5.1.1.3 IEEE 1394 Bus Characteristics

The high speed bus **shall** conform to the IEEE 1394-1995 specification. Extensions to the IEEE standard **shall** be minimized. Deviations and extensions to the standard **shall** be fully documented in the ABI – spacecraft ICD.

3.5.1.1.3.1 Spacecraft Acts as Bus Controller

The spacecraft **shall** act as the bus master with the ABI acting as a bus slave.

3.5.1.1.3.2 Node Address

The ABI **shall** use one (1) IEEE-1394 node address. The IEEE-1394 node electronics **shall** be part of the instrument.

3.5.1.1.3.3 IEEE 1394 Medium

The cable medium option of the IEEE 1394 **shall** be used. The connector type, wire type and pin assignment **shall** be specified by the vendor and documented in the ABI-spacecraft ICD.

3.5.1.1.3.4 Mode of Data Transfer

The ABI **shall** utilize the asynchronous IEEE 1394 data transfer mode.

3.5.1.1.3.5 High Speed Data Buffering Due To IEEE 1394 Bus Timing

The ABI **shall** provide sufficient internal buffering to accommodate a maximum of **TBS** msecs delay in the initiation of the IEEE 1394 data transfer by the bus controller.

3.5.1.1.3.6 Redundancy

Redundant IEEE 1394 buses **shall** be provided. Selection of the active IEEE 1394 bus **shall** be by command received by the ABI instrument over the command and telemetry bus.

3.5.1.1.3.7 Fault Tolerance

No single failure on the ABI IEEE 1394 electrical interface or the spacecraft side of the interface **shall** prevent the ABI from communicating with the spacecraft over either the primary or secondary bus.

3.5.1.2 Standard Interface for Command and Telemetry

Dual Redundant MIL-STD 1553B interfaces and/or redundant I^2C interfaces **shall** be provided for the receipt of CCSDS packetized instrument commands, time code messages and to provide CCSDS packetized instrument engineering data such as housekeeping information, status and processor dumps and any other data for inclusion in the real time spacecraft telemetry stream. The Command and Telemetry interface **shall** be used for the transfer of spacecraft attitude error information, instrument angular motion and other spacecraft ancillary information for inclusion in the high speed sensor downlink.

3.5.1.2.1 Spacecraft Acts As Bus Controller/Bus Master

The spacecraft **shall** be the bus controller (1553-B)/bus master(I^2C) for all transactions on the command and telemetry bus.

3.5.1.2.2 Remote Terminal Address

The ABI instrument **shall** utilize one (1) 1553B RT address and/or one (1) I^2C slave address. The RT circuitry **shall** be part of the instrument.

3.5.1.2.3 Selection of the Active Command and Telemetry Bus

Upon initial power up of the ABI instrument, the ABI **shall** use command and telemetry bus 1 as the active bus. Switching between the inactive and active command and telemetry buses **shall** be performed upon receipt of a discrete command from the spacecraft (**TBR)**.

3.5.1.2.4 Data Retransmission

In the event of an error in the transmission of data or command packets between the ABI instrument and the spacecraft, the following **shall** occur:

a. If the 1553B bus is used, the Bus Controller **shall** retry on the active side n times (**TBD**). A ground command will be used to switch to the other side of the bus if required to clear the fault condition (**TBD)**.
b. If the I^2C bus is used, **TBD.**

3.5.1.2.5 Data Buffering for each Bus

The instrument **shall** provide internal buffering to store 2 CCSDS packets or 2 seconds of data, which ever is more (**TBR)**.

3.5.1.2.6 Instrument Modes and Engineering Data Rates

The data bandwidth allocated to the ABI instrument over the standard command and telemetry bus is a function of instrument and/or spacecraft operating mode. The allocation is **TBD**.

3.5.1.2.7 ABI Housekeeping Telemetry

ABI instrument telemetry is divided into “Critical” telemetry and “Non-Critical” telemetry. Critical telemetry is that instrument related data such as temperature data, power status that needs to be sampled by the spacecraft even if the instrument is unpowered in order to determine its safety. “Non-Critical” telemetry is that data that is not required to be sampled unless the instrument is powered with the standard bus active.

3.5.1.2.7.1 ABI “Non-Critical” Telemetry

All non-critical ABI instrument engineering data **shall** be formatted in CCSDS packets and relayed to the spacecraft over the standard bus. The packet structure **shall** include a method for detecting any bus transmission errors if the selected standard bus does not provide such a feature.

3.5.1.2.7.2 ABI "Critical" Telemetry

Critical telemetry will be directly sampled and formatted by the spacecraft into it's PCM housekeeping telemetry. The spacecraft **shall** provide **TBD** passive analog channels, **TBD** bilevel channels and **TBD** active analog channels. All critical telemetry interfaces **shall** be redundant **(TBR).** The characteristics of these channels are **TBD.**

3.5.1.2.7.3 ABI Housekeeping Data Content

The ABI Housekeeping data content **shall** include all data necessary to monitor instrument health, to determine its status and diagnose anomalous conditions. This data **shall** include but not be limited to:

- Sensor mode and configuration
- Sensor temperatures
- Sensor power supply current and voltages
- Relay status, scan mirror status and other rotating mechanism rates
- Processor mode/status information

In addition, the ABI instrument **shall** have commandable modes which affect the selection of the data for downlink. For instance, the ABI **shall** include a dwell capability. Upon receipt of a dwell command which specifies the telemetry item, the ABI **shall** sample the specified data item at a rate of up to 10 samples/second if the formatting is defined by the ABI.

3.5.1.2.8 ABI Instrument Commands

ABI commands are divided into "Critical" and "Non critical" commands. Critical commands are those commands that are necessary to configure the instrument when it is off, reset instrument operation when it is not responding to commands over the standard command and telemetry bus and commands to pyrotechnic devices. "Non critical" commands are those commands that are normally issued over the standard bus such us configuration changes, memory loads, etc.

3.5.1.2.8.1 ABI "Non-critical" Commands

All ABI commands issued over the standard bus **shall** be formatted as CCSDS command packets. The command packet structure **shall** include a method for detecting any bus transmission errors if the selected standard bus does not provide such a feature.

3.5.1.2.8.2 ABI "Critical" Commands

All ABI critical commands **shall** utilize redundant dedicated command interfaces (**TBR)**. They **shall** be limited to pulse commands (**TBR).** Potentially hazardous commands, such as pyrotechnic commands, **shall** require separate enable and execute commands. The enabled function **shall** be disabled by the ABI instrument or the spacecraft after **TBD** seconds. The electrical characteristics of the command interface are **TBD.**

3.5.1.2.9 Spacecraft Attitude and Housekeeping Data

The ABI instrument **shall** ingest Spacecraft Motion Compensation attitude information, instrument mounting surface Angular Displacement Sensor data and spacecraft housekeeping information formatted as CCSDS packets over the Command and Telemetry interface. The maximum aggregate rate of this data is 50 Kb/s (**TBD**) that must be included in the sensor data to the spacecraft. The frequency of the occurrence of this data is **TBD.**

3.5.1.2.10 Time Code Data and Synchronization

The spacecraft **shall** provide time code data using CCSDS formatted packets over the standard command and telemetry bus. The format of the time code words **shall** be based on universal time coordinated (UTC) and conform to one of the CCSDS time code standards. The time code message **shall** be transmitted once per second. Absolute time correlation **shall** be 1 millisecond with 1 microsecond as a goal. The method of synchronizing the time code message to a "time mark" is **TBD.**

3.5.1.2.11 Fault Tolerance

No single failure on the ABI side of the command and telemetry electrical interface or the spacecraft side of the interface **shall** prevent communication over either of the primary or secondary bus.

3.5.1.2.12 Scan Status

The instrument **shall** provide information on scan status to the spacecraft over the standard buss formated into CCSDS packets. Scan status information will include, but not be limited to: Scan Active, Star data acquisition, Slew in process, Black Body calibration in process, etc.

3.5.1.3 Ground Support Equipment Interfaces

The ABI **shall** provide ground support equipment (GSE) interfaces that are intended to be used during “off the spacecraft” testing. The primary use of this interface is to provide an alternate way to interrogate, load and control the operation of any ABI embedded flight processor. The GSE interfaces **shall** be commercially available and use a commercial protocol. Acceptable interfaces include TCP/IP over Ethernet and UART RS-422.

3.5.2 "Conventional" , Current GOES Interfaces Requirements

This section describes the " conventional", current GOES interface requirements, and will be updated after the GOES Project reviews the industry trade studies on implementing standard interfaces on the GOES ABI instrument. These interface requirements are based on the current GOES interface requirements, but should only be used as an example of potential spacecraft interfaces.

3.5.2.1 Commands

The spacecraft **shall** control instrument operations by providing commands provided to the instrument from primary and redundant spacecraft command units respectively.

3.5.2.1.1 Bilevel Command

The spacecraft **shall** provide the instrument with bilevel commands. Levels and impedance are **TBD**.

3.5.2.1.2 Pulse Commands

The instrument **shall** respond to signal pulses from either command unit and **shall** continue to function should a single command unit fail in the low condition. Levels and impedance are **TBD**.

3.5.2.1.3 Relay Driver Commands

The spacecraft will provide current to energize command relays in the ABI. Levels and impedance are **TBD**.

3.5.2.1.4 Electroexplosive Device Command

The spacecraft **shall** provide redundant EED commands to the instrument in order to energize any electroexplosive devices (EED) required by the ABI. Command verification **shall** be provided in the instrument’s bilevel telemetry by sensing the mechanism's status using position switches. Levels and impedance are **TBD**.

3.5.2.1.5 Serial Commands

The spacecraft will provide redundant Serial commands to the ABI to configure the instrument. These commands may be on 3 wires with clock, data and enable lines or as a single wire serial bit stream. Levels and impedance are **TBD**.

3.5.2.2 Telemetry

The instrument **shall** provide the required telemetry interfaces. The following sections define the requirements for the telemetry, which interfaces directly to the spacecraft and not the status, or housekeeping telemetry, which is included in the ABI wideband data.

3.5.2.2.1 Bilevel Telemetry Outputs

The Relay and Switch Bilevel and Transistor bilevel outputs **shall** be provided. Levels and impedance are **TBD**.

Relay and switch bilevel telemetry **shall** be valid in all operating modes including Standby and Instrument OFF. Transistor Bilevel Telemetry **shall** become Valid with the Safe Hold Mode command.

3.5.2.2.2 Relay and Switch Bilevel Telemetry Signal Characteristics

Relay and switch bilevel telemetry **shall** be made available for spacecraft monitoring at all times. Levels and impedance are **TBD**.

3.5.2.2.3 Analog Telemetry

The instrument **shall** monitor analog telemetry signals generally temperatures, voltages, and currents and provide Analog Telemetry outputs to the spacecraft. Analog Telemetry outputs in units of Volts will be converted by ground processing to engineering units (degree C, Kelvin, amps, volts) through the use of conversion equations and instrument unique telemetry coefficients provided by the instrument contractor. Levels and impedance are **TBD**.

3.5.2.2.4 Wideband Data (Instrument Science Data Output)

The wideband data **shall** be packetized using CCSDS protocols and the output **shall** be redundant. Levels and impedance are **TBD**.

3.5.2.3 Image Navigation and Registration Interface

The spacecraft's image navigation and registration (INR) system **shall** interface to the instrument. The spacecraft Motion Compensation (SMC) signal may be analog or digital or both. The instrument may move the scan mirror in response to the SMC signals from the spacecraft. This SMC signal will only carry information as to the low frequency angular motions of the Spacecraft in its X, Y, Z coordinate frame that may be used to affect the Line Of Sight of the ABI if desired to minimize the required overscan.

3.5.2.3.1 Spacecraft Attitude Data

Digital information of the spacecraft attitude (50kb/s **TBD**) **shall** be received by the instrument and **shall** be included in the wideband data stream. Levels and impedance are **TBD**.

3.5.2.3.2 Scan Status

The instrument **shall** provide information on scan status to the spacecraft. Scan status information will include, but not be limited to: Scan Active, Star data acquisition, Slew in process, Black Body calibration in process, etc. Levels and impedance are **TBD.**

3.5.3 Operations Database Requirements

The Satellite System Engineering Database (SSED) **shall** include the flight telemetry and command database requirements for the ABI.

3.6 Contamination Control - Spacecraft Contractor

The spacecraft contractor **shall** comply with the **TBD** requirements in order to prevent contamination from degrading the optical and thermal surfaces of the ABI .

3.6.1 Space Craft Contractor

3.6.1.1 Facility Requirements, TBR

The instruments **shall** be processed in a Class M6.5 (100,000) cleanroom (at 0.5 µm and 5.0 µm per Fed-Std 209). Airborne particle counts **shall** be taken at least once per week during Class M6.5 (100,000) operations. During operations that require exposure of contamination sensitive optical or thermal surfaces, the instruments **shall** be maintained in a Class M5.5 (10,000) cleanroom (at 0.5 µm and 5.0 µm per Fed-Std-209). The functional goal **shall** be Class M4.5 (1000) in actual practice. Airborne particle counts **shall** be taken at least once per hour during Class 10,000 operations. The instruments **shall** be maintained in relative humidity environment between 30 and 60%.

3.6.1.2 Equipment Requirements

Spacecraft test and ground support equipment **shall** be designed to preclude contamination of the instrument. Potential contamination sources such as thermal/vacuum targets and insulation blankets **shall** be vacuum baked prior to use with the instrument

3.6.1.3 Purge Requirements

The spacecraft contractor **shall** provide a gas purge to the instrument optical cavity during all operations at the spacecraft facility(s), launch site, and during transportation (prior to fairing encapsulation) and storage if required by the ABI

3.6.1.4 Ground Storage Requirements

During storage and transportation periods, the instrument **shall** be bagged in ESD protective material. Witness samples representative of the instrument sensor module surface **shall** be examined and changed every six months during extended storage periods

3.6.2 Spacecraft and Mission Considerations

3.6.2.1 Spacecraft and Mission Design Requirements

. Multilayer insulation and spacecraft vents **shall** be directed away from the instrument optical port and radiant cooler. All spacecraft components (such as insulation blankets, harnesses, and painted surfaces) with the potential to contaminate the instrument optical and thermal surfaces **shall** be vacuum baked prior to thermal vacuum testing with the instrument.

Protective and/or preventative measures **shall** be taken to preclude particulate contamination of the optical cavity and radiant cooler during launch and orbit raising.

The effects of direct or reflected ultraviolet radiation on the contamination of the optical and thermal surfaces of the instrument **shall** be considered in the design of on-orbit operations including storage and safe hold modes.

3.6.2.2 Particulate Contamination

The spacecraft **shall** contribute no more than 0.02% area particle coverage to the “virtual” surface of the instrument optical aperture. These requirements **shall** be interpreted as the total allowable end-of-life contribution from the spacecraft, launch vehicle, and spacecraft facility(s) to instrument contamination over the sum of all ground processing, launch, orbit raising, and mission activities.

3.6.2.3 Molecular Contamination

The spacecraft **shall** contribute no more than 1.0 mg/ft^2 (100 Å) nonvolatile residue to the instrument radiant cooler, and the “virtual” surface of the instrument optical aperture. This requirement **shall** be interpreted as the total allowable end-of-life contribution from the spacecraft, launch vehicle, and spacecraft facility(s) to instrument contamination over the sum of all ground processing, launch, orbit raising, and mission activities. This requirement **shall** include contamination from all sources including spacecraft outgassing and plume impingement.

3.7 Shielding Radiation Environment

The instrument **shall** be designed to survive ionization and displacement damage produced by the expected space radiation environment as defined in the Performance and Operation Requirements Document during it's mission life.

3.8 Magnetic Field Emissions

The change in the magnetic field produced by the sensor, electronics, or power supply modules, **shall** be less than 30 nanoTesla peak-to-peak, for any instrument operating mode, up to a single-pole lowpass bandwidth of 1.0 Hz, in any axis when measured at a distance of 1 meter from any face of the modules. The limit for any non-operating modes such as Scan Power On and Scan Reset transients **shall** be less than 50 nanoTesla. The GOES spacecraft carries a very sensitive magnetometer.

3.9 Launch Environments

3.9.1 Thermal

The thermal environment during launch is **TBS**.

3.9.2 Barometric Pressure

The instrument **shall** be designed for an environment that is between 1 x 10^{-10} mm Hg (Torr) and 815 mm Hg. The maximum barometric pressure increase **shall** be 14 mm Hg/sec, and the maximum barometric pressure decrease **shall** be 56.9 mm Hg/sec. For the maximum decrease in barometric pressure, there **shall** be a 2X design margin as shown by analysis. If a 2X margin cannot be shown by analysis, a test **shall** be performed. The pressure decrease rate used in the test **shall** be 1.12 times the maximum rate. The minimum pressure and the maximum barometric pressure increase requirements **shall** be used for detailed design and the selection of materials but **shall** not be demonstrated or tested in any way.

3.9.3 Mechanical Environments

Maximum loads for the Imager Sensor Module, Electronics Module and Power Supply Module **shall** not exceed the nominal values defined in Tables 3.9.3.1.1, 3.9.3.1.2, 3.9.3.2.1 and Figures 3.9.3.4.1 and 3.9.3.5.1. Vibration and shock levels stated in Tables 3.9.3.1.1, 3.9.3.1.2, 3.9.3.2.1 and Figures 3.9.3.4.1 and 3.9.3.5.1 **shall** not be exceeded for any test, launch, or transportation environment. 3.9.3.1 Random vibration.

3.9.3.1 Random Vibration

Table 3.9.3.1.1 and Table 3.9.3.1.2 provide the protoflight and prototype qualification random vibration levels to which the instruments and components **shall** be exposed during testing. Protoflight test duration **shall** be 1 minute for each axis. Prototype qualification test duration **shall** be 2 minutes for each axis. Acceptance test levels are 3 dB less than those shown in Table 3.9.3.1.1 with a duration of 1 minute for each axis. At no time **shall** any instrument or component be tested to levels less than the minimum workmanship levels specified in Table 3.9.3.1.2.

Table 3.9.3.1.1. Random Vibration Test Levels

Protoflight Vibration Test Levels	
Frequency (Hz)	ASD (g^2/Hz)
20	0.026
20-50	+6dB/oct
50-800	0.16
800-2000	-6dB/oct
2000	0.026
Overall	14.1 G_{rms}

The acceleration Spectral Density level may be reduced for components weighing more than 22.7-kg (50 lb) according to:

	Weight in kg	**Weight in lb**
dB reduction	10 log(W/22.7)	10 log(W/50)
ASD (50-800 Hz)	0.16(22.7/W)	0.16(50/W)

Where W = component weight.

The slopes **shall** be maintained at + and –6dB/oct for components weighing up to 59-kg (130-lb). Above that weight, the slopes **shall** be adjusted to maintain an ASD level of 0.01g2/Hz at 20 and 2000 Hz.

For components weighing over 182-kg (400-lb), the test specification will be maintained at the level for 182-kg (400 lbs).

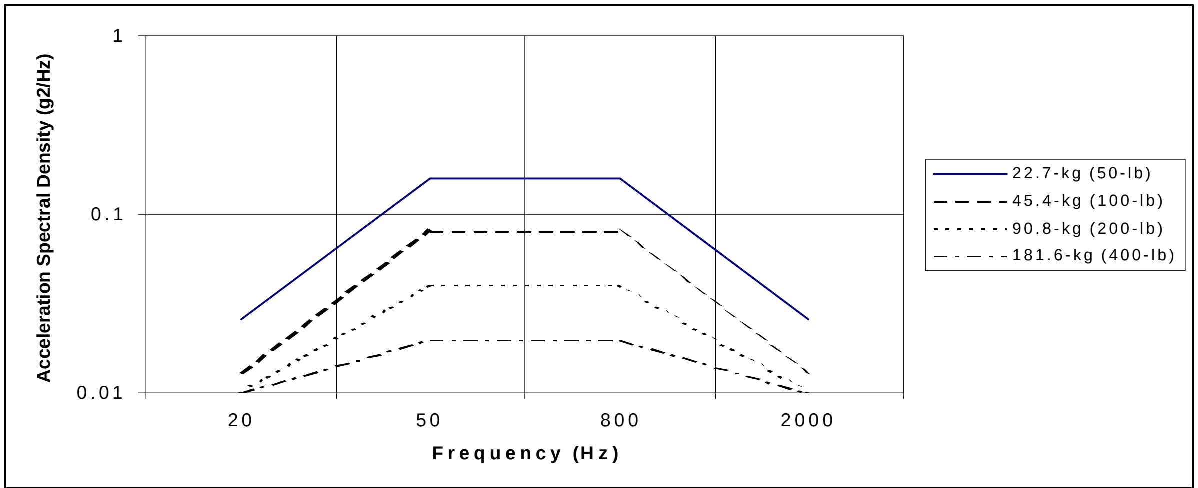


Table 3.9.3.1.2. Random Vibration Workmanship Test Levels

Minimum Workmanship Vibration Test Levels	
Frequency (Hz)	ASD (g^2/Hz)
20	0.01
20-80	+3dB/oct
80-500	0.04
500-2000	-3dB/oct
2000	0.01
Overall	6.8 G_{rms}

The plateau acceleration spectral density level (ASD) may be reduced for components weighing between 45.4 and 182 kg, or 100 and 400 pounds according to the component weight (W) up to a maximum of 6 dB as follows:

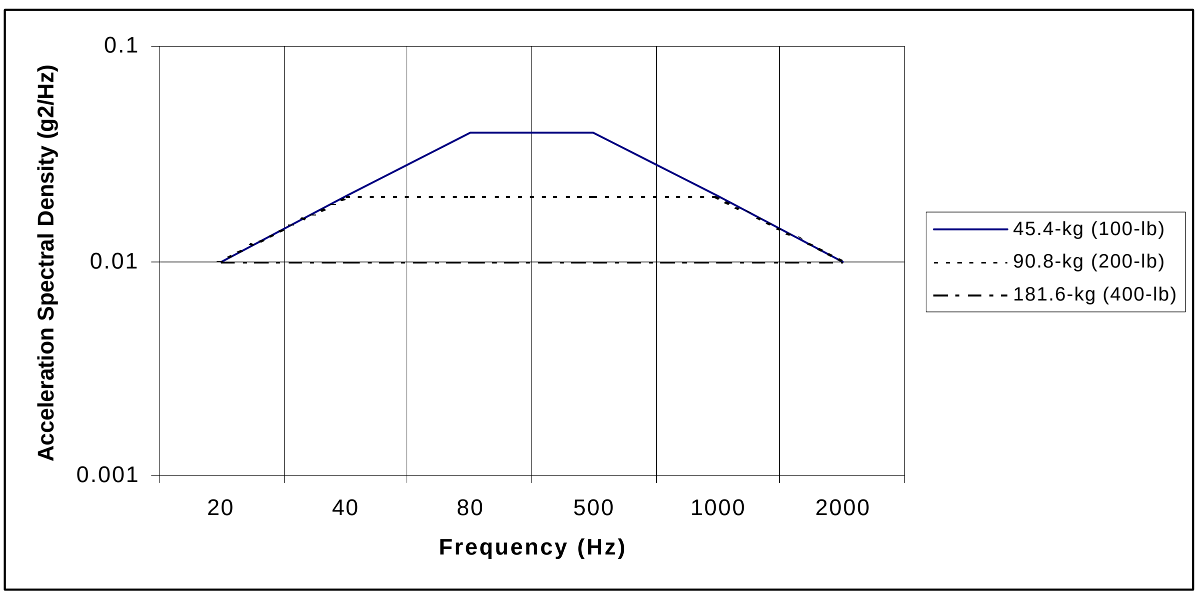
	Weight in kg	**Weight in lb**
dB reduction	10 log(W/45.4)	10 log(W/100)
ASD $_{(plateau)}$ level	0.04(45.4/W)	0.04(100/W)

The sloped portions of the spectrum **shall** be maintained at + and –3dB/oct.Therefore, the lower and upper break points, or frequencies at the ends of the plateau become:

F_L =80 (45.4/W) [kg] F_L = frequency break point low end of plateau
=80 (100/W) [lb]

F_H =500 (W/45.4) [kg] F_H = frequency break point high end of plateau
=500 (W/100) [lb]

The test spectrum **shall** not go below 0.01G^2/Hz. For components whose weight is greater than 182-kg or 400 pounds, the workmanship test spectrum is 0.01 G^2/Hz from 20 to2000 Hz with an overall level of 4.4 G_{rms}.



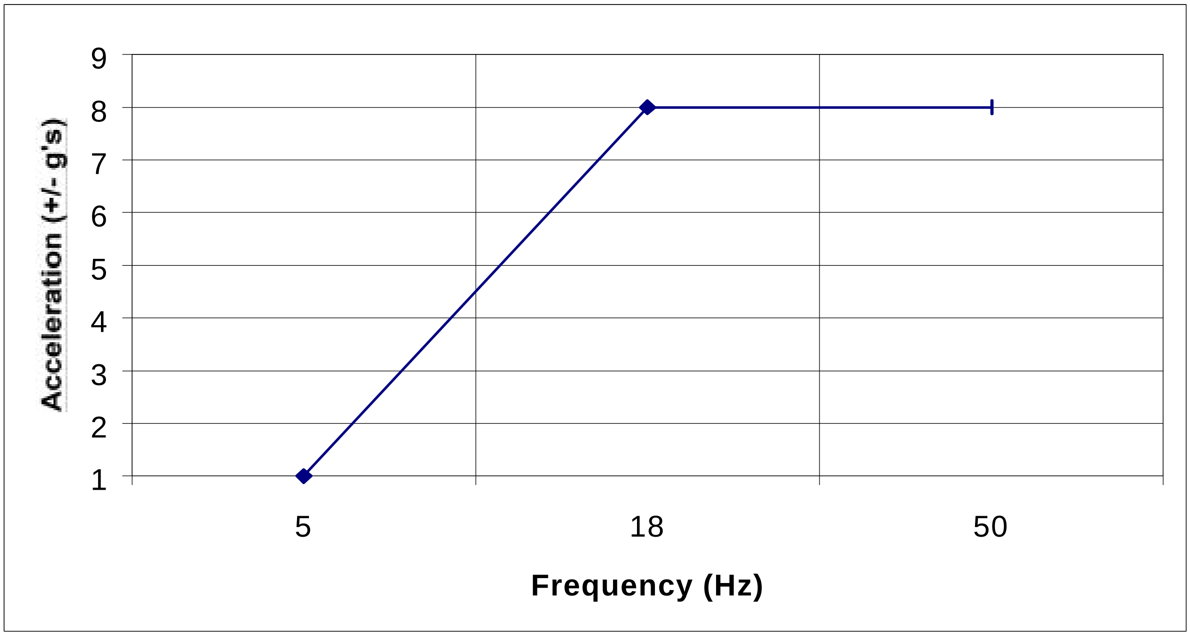
3.9.3.2 Sine Vibration

The instrument or component **shall** be subjected to protoflight/qualification sine vibration test levels specified in Table 3.9.3.2.1 in each of three orthogonal axes. During this test the instrument or component **shall** be in the launch configuration. There **shall** be one sweep from 5 Hz to 50 Hz for each axis. The protoflight sweep rate **shall** be 4 oct/min. For prototype qualification testing, the sine vibration levels **shall** be the same as protoflight levels but with the sweep rate reduced by a factor of 2 to 2 oct/min.

Some type of response limiting would be allowed whether it be notching or force limiting.

Table 3.9.3.2.1 Sinusoidal Protoflight Test Levels

Frequency	Amplitude/Acceleration
5 - 18	Displacement = 12 mm (double amplitude)
18 – 50	8 G peak



3.9.3.3 Design Strength Qualification

The instrument or component **shall** be tested to a set of loads equal to 1.25 times the predicted loads from a coupled flight loads analysis. Acceleration testing, static load testing, or vibration testing may apply these loads.

3.9.3.4 Shock

The instrument or component **shall** be designed to meet performance requirements following exposure to the shock environment specified in Figure 3.9.3.4.1. Instrument or component **shall** be designed to survive a peak of 1200 G's without permanent performance degradation. This is the environment at the instrument interface, not the spacecraft/launch vehicle interface.

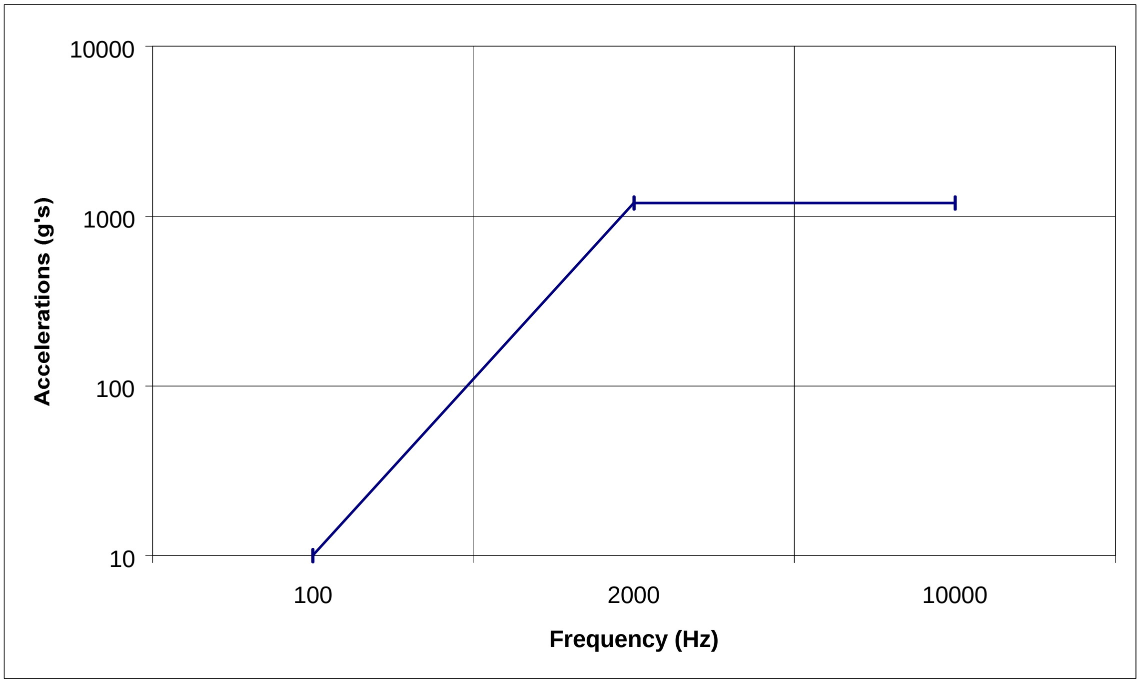


Figure 3.9.3.4.1. Shock Spectrum

3.9.3.5 Acoustics

The instrument or component **shall** be designed to survive the protoflight acoustic levels shown in Table 3.9.3.5-1. Acceptance acoustic levels are 3 dB less than protoflight as shown in Table 3.9.3.5-1. Test duration **shall** be 1 minute for acceptance and protoflight testing and 2 minutes for prototype qualification. Testing at the instrument level will be required only if there are elements in the ABI that may fail during the spacecraft acoustic test environment.

Table 3.9.3.5-1. GOES S/C Acoustic Environment

One-Third Octave Band Center Frequency, Hz	GOES Acceptance Level, dB*	GOES Protoflight Level, dB*	Test Tolerance, dB*
25	114	117	+3/-3

31.5	125.4	128.4	+3/-3
40	125.4	128.4	+3/-3
50	125.2	128.2	+3/-2
63	126.3	129.3	+3/-2
80	128	131	+3/-2
100	129.8	132.8	+3/-2
125	130	133	+3/-2
160	131.5	134.5	+3/-2
200	131.6	134.6	+3/-2
250	130.5	133.5	+3/-2
315	130	133	+3/-2
400	130.1	133.1	+3/-2
500	129.9	132.9	+3/-2
630	128.3	131.3	+3/-2
800	127	130	+3/-2
1000	124	127	+3/-2
1250	122	125	+3/-2
1600	120.5	123.5	+3/-2
2000	121.8	124.8	+3/-2
2500	118	121	+3/-2
3150	117.5	120.5	+3/-3
4000	115.5	118.5	+3/-3
5000	114.5	117.5	+3/-3
6300	113.8	116.8	+3/-3
8000	114	117	+3/-3
10000	114.8	117.8	+3/-3
Overall SPL, dB	141.2	144.2	± 1.5
Duration, sec	60	60	+10%/-0%

* Reference pressure = 20 μPa

** Max acoustic environment (LPF, without acoustic blankets), acceptance test levels, duration,

Protoflight test margin/duration from: Atlas Launch System Mission Planner's Guide, Rev 6, February 1997, Lockheed Martin CLS.

*** Max acoustic environment from: Delta III Max Acoustic Acceptance Levels Users Guide (GOES N-Q IRD 20 March 98) Acceptance Test Duration, Protoflight Test Margin/Duration from: Delta III Payload Planner's Guide, MDC 95H0137, April 1996, McDonnell Douglas Aerospace